(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: 0 456 206 A2

(12) EUROPEAN PATENT APPLICATION

(21) Application number: 91107476.3

(51) Int. Cl.5: H04L 12/42

(22) Date of filing: 08.05.91

(30) Priority: 09.05.90 JP 119524/90

(43) Date of publication of application:
13.11.91 Bulletin 91/46

(84) Designated Contracting States:
DE FR GB

(71) Applicant: FUJITSU LIMITED
1015, Kamikodanaka Nakahara-ku
Kawasaki-shi Kanagawa 211(JP)

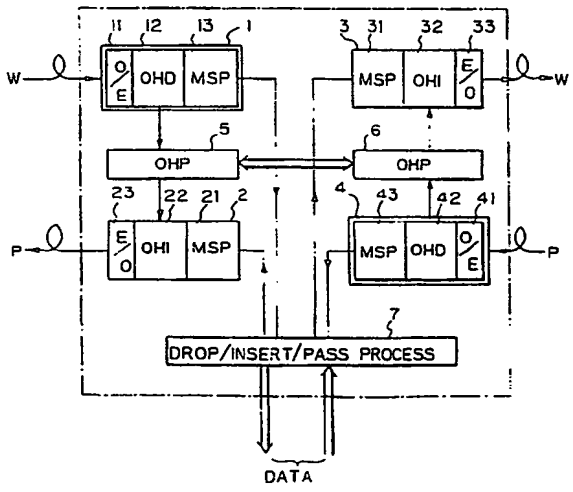
(72) Inventor: Yamashita, Haruo
24-4, Sumiregaoka, Kouhoku-ku
Yokohama-shi, Kanagawa 223(JP)
Inventor: Takizawa, Yuji
426, Shibokuchi, Takatsu-ku
Kawasaki-shi, Kanagawa 213(JP)
Inventor: Yamaguchi, Kazuo
12-21, Toyohara-cho
Hiratsuka-shi, Kanagawa 254(JP)

(74) Representative: Lehn, Werner, Dipl.-Ing. et al
Hoffmann, Eitle & Partner Patentanwälte
Arabellastrasse 4
W-8000 München 81(DE)

(54) Fault recovery system of a ring network.

(57) A fault recovery system of a ring network based on a synchronous transport module transmission system, having a fault data writing unit (22,32) for writing, when an input fault is detected by a node, fault data (F1(#n,#k,S)) in a predetermined user byte (UB) in an overhead of a frame flowing through both a working line (W) and a protection line (P) running in opposite directions to each other, and, by detecting the fault data in a supervision node or a node just before the fault position, the supervision node or the node just before the fault position excecutes a loopback operation.

Fig. 7



EP 0 456 206 A2

BACKGROUND OF THE INVENTION

(1) Field of the Invention

The present invention relates to a fault recovery system of a ring network, and more particularly to a fault recovery system of a ring network based on a synchronous transport module (STM) transmission system called a new synchronization system.

Ring networks based on the synchronous transport module (STM) transmission system such as a synchronous digital hierarchy (SDH) or synchronous optical nwework (SONET), the standardization of which has been developped in the CCITT or United States T1 Committee, are expected to be applied to subscriber systems (Urban Networks) in the future. The STM transmission system is applied to a high speed and broad band system of more than 155.52 Mbps. When a ring network, based on such a STM transmission system which is a high speed and broad bandan optical transmission system, is constructed, the ability of survive a fault in the network is important and should be considered from the beginning of the construction of the system, since a network fault can have a great influence on the modern information society.

(2) Description of the Related Art

As a conventionally proposed network fault recovery system, there are recovery systems employing a loopback used in a local area network (LAN) and so forth. These conventional recovery systems, however, are networks based on packet communication through predetermined protocols, and therefore, there are problems in that it takes a long processing time of several seconds to recover from a fault because the fault must be recovered by the use of the above-mentioned predetermined protocols. Since the recovery time in a new synchronization system should be shorter than, for example, 50 msec, a recovery method which uses these protocols cannot be employed in a new synchronization system.

On the other hand, for point to point communication, the standard usage of automatic protection scheme (APS) bytes (K1 and K2 bytes in an STM frame) for a switching control between a working line and a protection line has been recommended by the CCITT or the United States T1 Committee. For application to a ring network, however, standard usage has not been proposed.

A fault recovery system applied to a ring network is disclosed in Japanese Patent Publication 1-45782, published on October 4, 1989. This fault recovery system, however, is not applied to the STM transmission system. Further, in this document, if multiple faults occur in the working line and the protection line, the positions of the faults cannot be determined.

SUMMARY OF THE INVENTION

Accordingly, the present invention has an object to provide, based on the synchronous transport module (STM) transmission system, a system for rapidly and efficiently recovering a ring network even when multiple faults occurs.

There is provided, according to the present invention, a fault recovery system of a centralized control type ring netowrk based on a synchronous transport module transmission system. The ring network comprises: optical fiber transmission lines including a working line and a protection line running in opposite directions to each other; a plurality of drop/insert nodes connected to each other through the optical fiber transmission lines; and a supervision node, connected through the optical fiber transmission lines to the drop/insert nodes.

Each of the drop/insert nodes has: an input fault detecting unit for detecting an input fault on the working line or the protection line; a fault data writing unit for writing, when the input fault is detected by the input fault detecting unit, fault data in a predetermined user byte in an overhead of a frame flowing through both the working line and the protection line; and a user byte passing unit for passing the user byte as is, when an input fault is not detected by the input fault detecting unit, through the node. The supervision node has: a fault data detecting unit for detecting the fault data in the user byte transmitted from the node which has detected the input fault trough the downstream sides of the working line and the protection line of the node which has detected the input fault; a fault position determining unit for determining, based on the fault data detected by the fault data detecting unit, a node which has detected the input fault; a writing unit for writing, into the user bytes, loopback requests for requesting nodes located immediately downstream and upstream of the fault position and closest to the supervision node, to execute loopback operations; and a sending unit for sending the loopback requests through the working line and the protection line to the nodes located immediately downstream and upstream of the fault position and closest to the supervision node. By this construction, the nodes located immediately downstream and upstream of the fault position and closest to the supervision node execute loopback operations to recover from the fault.

According to another aspect of the present invention, there is provided a fault recovery system of a distributed control type ring netowrk based on a synchronous transport module transmission sys-

BNSDOCID <EP 0456206A2 >

tem. The distributed controlled type ring network comprises: optical fiber transmission lines including a working line and a protection line running in opposite directions to each other; and a plurality of drop/insert nodes connected to each other through the optical fiber transmission lines. Each of the drop/insert nodes has: an input fault detecting unit for detecting an input fault on the working line or the protection line; a fault data and loopback request writing unit for writing, when the input fault is detected by the input fault detecting unit, fault data and a loopback request in a predetermined user byte in an overhead of a frame flowing through both the working line and the protection line; a loopback executing unit for executing, based on the fault data detected by the fault data detecting unit, a loopback when the node is located immediately upstream of the input fault and adjacent to a node which has not detected an input fault. The node executing the loopback returns, in response to the loopback request, a loopback response by the use of the predetermined user byte to the node which has detected the input fault.

By this construction also, the nodes located immediately upstream of the fault position and adjacent to a node which has not detected an input fault execute loopback operations to recover from the fault.

It is preferable that the synchronous transport module transmission system is the system according to the recomendation of CCITT G.707, 708, and 709.

It is preferable that the fault data includes a node identification number for identifying the node which has detected the input fault.

It is preferable that the fault data includes fault line information indicating whether the input fault has occurred on the working line or on the protection line.

It is preferable that the fault data includes fault reporting information.

It is preferable that the loopback requests are formed by rewriting the fault data to include a node identification number of a node at which the loopback should be executed, and loopback request information.

It is preferable that the loopback requests are formed by using another byte other than the predetermined user byte in the overhead of the frame.

It is preferable that the other byte in the overhead of the frame is the K1 byte or the K2 byte according to the recommendation of CCITT G.707, 708, and 709.

It is preferable that the writing unit has a rewriting unit for rewriting the fault data transmitted through the working line into a first loopback request and for rewriting the fault data transmitted through the protection line into a second loopback request, and the sending unit has unit for sending the first loopback request through the protection line and for sending the second loopback request to the working line.

It is preferable that the ring network is a bidirectional ring network comprising a pair of clockwise and counterclockwise working lines and a pair of counterclockwise and clockwise protection lines.

It is preferable that the system comprises a plurality of pairs of the working lines and a single pair of the protection lines.

According to still another aspect of the present invention, there is provided a fault recovery system of a hybrid type ring network based on a synchronous transport module transmission system. In the hybrid type ring network, the ring network comprises: optical fiber transmission lines including a working line and a protection line running in opposite directions to each other; and a plurality of drop/insert nodes connected to each other through the optical fiber transmission lines. Each of the drop/insert nodes comprises a selecting unit for dropping the input signal from the protection line when the input signal from the working line is faulty, for dropping the input signal from the working line when the input signal from the protection line is faulty, and for dropping the input signal from the working line when both are normal, and passing the signal as it is when the signal is not to be dropped.

BRIEF DESCRIPTION OF THE DRQWINGS

The above object and features of the present invention will be more apparent from the following description of the preferred embodiments with reference to the accompanying drawings, wherein:

Figure 1 is a format diagram of an overhead of the STM frame used in a fault recovery system of a ring network according to the present invention;

Figs. 2A to 2C are principal construction diagrams of the fault recovery system of a centralized control type ring network according to an embodiment of the present invention;

Figs. 3A to 3C are principal construction diagrams of the fault recovery system of a distributed control type ring network according to another embodiment of the present invention;

Figs. 4A to 4D are diagrams showing examples of various ring constructions used in the present invention;

Fig. 5 is a principal construction diagram of the fault recovery system of a hybrid ring according to still another embodiment of the present invention;

Figs. 6A to 6C are diagrams for explaining an F1

BNSDOCID: <EP 0456206A2 I >

byte in the overhead used in the present invention;

Fig. 7 is a block diagram showing a construction example of a drop/insert node and a supervision node constructing the centralized control type or the distributed control type ring according to the present invention;

Figs. 8A to 8C are diagrams showing an example of a break in the working line causing a fault in the centralized control type ring according to still another embodiment of the present invention;

Figs. 9A to 9C are diagrams showing an example of breaks in both the working line and the protection line causing a fault in the centralized control type according to still another embodiment of the present invention;

Figs. 10A to 10C are diagrams showing an example of when plural faults occur in the centralized control type ring according to still another embodiment of the present invention;

Figs. 11A to 11C are diagrams showing an example when both the working line and the protection line are cut causing a fault in the distributed control type ring according to still another embodiment of the present invention;

Figs. 12A to 12C are diagrams showing an example when plural faults occur in the distributed control type ring according to still another embodiment of the present invention;

Fig. 13 is a block diagram showing a construction example of each drop/insert node in the hybrid ring used in the system of the present invention; and

Fig. 14 is a diagram showing evaluations of various fault states in the hybrid ring used in the system of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Currently, international standardization of the method of using the overhead bytes in the STM frame format of the synchronous transport module (STM) transmission system is being prepared. In view of this, the inventors of the present invention have considered using the overhead bytes for recovering faults in a ring network.

Namely, Fig. 1 shows a frame format of the above-mentioned STM (in particular the frame format of the STM-1), in which A1, A2, B1, B2, C1, D1-D12, E1, E2, K1, and K2 respectively represent bytes, usage of which is already internationally standardized. The other F1 byte and Z1 and Z2 bytes have not yet been internationally standardized but are determined to be used for domestic or national use. Note that the remaining bytes are assigned for domestic use.

Accordingly, in the present invention, by using the unused bytes such as the latter F1 byte or Z1 and Z2 bytes as user bytes (UB), these bytes can can be utilized to recover a fault in a ring network of the new synchronization system (hereinafter simply referred to as a ring network) constructed by optical fiber transmission lines forming a working line (W) and a protection line (P) running in opposite directions to each other.

In the Case of a Centralized Control Type Ring Network (Figs. 2A to 2C):

This ring network, as shown in Fig. 2A, is constructed by drop/insert nodes (nodes A-D for example in the figure, and hereinafter also referred to simply as nodes), and a supervision node SV. Throughout all the embodiments described in this specification, it is assumed that all of the nodes are provided in advance with node identification numbers. First, as shown in the figure 2A, when an input fault F (marked by x) of a working line W (or a protection line P as well) is detected by a node A by detecting a clock signal error and so forth, the node A writes fault data FD in a predetermined user byte UB in the overhead of each of the STM frames flowing through the working line W and the protection line P, and transmits the STM frames including the written fault data FD to the downstream sides of the working line W and the protection line P.

When the drop/insert node does not detect an input fault, it passes the user bytes as they are, and therefore, to the supervision node SV, the fault data FD in the user bytes UB are transmitted from the working line W and the protection line P.

The supervision node SV determines the position of the fault F by detecting and analyzing the fault data, as shown in Fig. 2B, and writes a loopback request LBR, requiring the nodes A and B located immediately downstream and upstream of the fault position and closest to the supervision node SV to execute loopback operations, into the user byte UB. The written loopback request LBR is transmitted through the protection line P and through the node D to the node A. The loopback request LBR is also transmitted through the working line W and through the nodes C and D to the node B.

As a result, as shown in Fig. 2C, the loopbacks are executed by these nodes A and B to recover the fault.

In this case, instead of utilizing the user byte UB for transmitting the loopback request, it may be possible to transmit the loopback request by using K1 and K2 bytes which are internationally standardized. In this case, it will conform with the international standardization.

BNSDOCID: <EP 0456206A2 I >

In the Case of a Distributed Type Ring Network (Figs. 3A to 3C):

In this ring network, there is no supervision node, and the respective drop/insert nodes are in an equal relation to each other.

Accordingly, as shown in Fig. 3A, when the drop/insert node A detects an input fault of the working line W (or of the protection line P as well), it writes fault data FD including a loopback request LBR into the user bytes UB in the STM frames of the working line W and the protection line P. The user bytes UB including the fault data FD and the loopback request LRB are transmitted to the downstream sides of the working line W and the protection line P.

In a similar way to that shown in Fig. 2A, the nodes C and D pass the user bytes UB as they are.

Among the respective nodes which received the fault data, the node B located immediately upstream of the input fault and adjacent to the node C which has not detected an input fault detects that there is a fault position at the output side of the node B so that, as shown in Fig. 3B, the node B executes the loopback operation and returns the loopback request LBR to the node A which transmitted the loopback requirement LBR.

When the node A receives the loopback request LBR, the node A executes the loopback operation based on the returned loopback request LBR so that, as shown in Fig. 3C, the loopback between the nodes A and B is completed and the fault is restored.

Note, in either of the centralized control type or distributed control type, not only the case where the ring network is constructed by a working line W and a protection line P corresponding to each other in a 1:1 relation as shown in Fig. 4A, but a unidirectional ring constructed by a plurality of working lines and a single protection line (W1-W3 and P1 in Fig. 4B) is also possible. A bidirectional ring is also possible which is constructed by a pair of clockwise and counterclockwise working lines W1 and W2 and a pair of counterclockwise and clockwise protection lines P1 and P2 as shown in Fig. 4C. Further, the fault can also be restored by constructing a bidirectional ring having a plurality of pairs of working lines W1 to W6 and a single pair of protection lines P1 and P2 as shown in Fig. 4D.

In the Case of a Hibrid-type Ring Network (Fig.5)

In this case also, similar to the distributed control type shown in Figs. 3A to 3C, there is no supervision node, and therefore the respective drop/insert nodes are in an equal relation to each other. As shown in Fig. 5, when a fault occurs in a point between the nodes A and B, the signal from the node A through the downstream side of the working line W is transmitted through the nodes D, E, and C until it is received by the node B, however,the signal from the node A through the protection line P continues to be transmitted through the loop if there is no countermeasure.

In the hybrid ring, a selecting unit is provided in each node for selecting a signal to be dropped as follows. Namely, in each node, if the input signal from the working line W indicates a fault, the input signal from the protection line P is dropped; if the input signal from the protection line P indicates a fault, the input signal from the working line W is dropped; and if both input signals are normal, the input signal from the working line W is dropped. If, however, the channel should not be dropped, it is passed as it is.

And, in this case, similar to the case of Figs. 2A to 2C and Figs. 3A to 3C, when each node detects an input fault in the working line W or the protection line P, fault data is written in the user bytes and is transmitted downstream of the working line W and the protection line P, and when an input fault is not detected, the user bytes are passed as they are, whereby, in the case of Fig. 5, the fault state between the nodes A and B can be evaluated with reference to the user bytes UB.

In the following, embodiments of a fault recovery system of a ring network relating to the present invention are described in more detail.

First, as a predetermined user byte in the overhead used in the system of the present invention, the F1 byte in the STM-1 frame format shown in Fig. 1 is used. This, however, may be the Z1 or Z2 byte assigned for the national use, or may be one utilizing various modifications.

Fig. 6A shows an embodiment of the F1 byte. In this embodiment, bits b1 and b2 are assigned as indicators. When the bit b1 is "0", it indicates whether there is a fault on the working line; and when it is "1", it indicates whether there is a fault on the protection line. When the bit b2 is "0", it indicates a fault report; and if the bit b2 is "1", it indicates that the node identification number of the node which should accept the loopback request (protection switching) is being conveyed. Also, the bits b3-b8 are assigned to the identification number of a node for identifying the node relating to the fault.

In an F1 byte as above, since only 6 bits can be used as node number data, when the number of nodes exceeds $2^6 = 64$, it is impossible to identify all nodes using the 6 bits. In this case, two continuous bytes, i. e., a first F1 byte and a second F1 byte of 12 bits as shown in Fig. 6B, may be utilized. The heading bit b1 of the first F1 byte is defined as "0" so that the first F1 byte conveys

BNSDOCID: <EP 0456206A2 I >

fault data relating to the working line W, and the heading bit b1 of the second byte F1 is defined as "1" so that the second F1 byte conveys fault data relating to the protection line P. These bytes are respectively used for detecting faults on the working line P and the protection line W. An example of the first F1 byte and the second F1 byte is shown in Fig. 6C, wherein (1) shows that both the working line and the protection line are in normal states, (2) shows that the node "3" on the protection line has detected an input fault because the bits b7 and b8 in the second F1 byte are "1", and (3) shows that the node "1" on the working line has detected an input fault because the bit b8 in the first F1 byte is "1".

In the following description, for the sake of simpicity, the first F1 byte and the second F1 byte are combined and indicated as F1(#n,#k,S) as shown in Fig. 6D, where #n indicates a node number which has detected a fault on the working line, #k indicates a node number which has detected a fault in the protection line, and S indicates whether the data indicates a fault report ("0") or a loopback request ("1").

In the following, by using the above-mentioned F1 byte, the fault recovery system in the above-described respective rings will be described.

Centralized Control Type Ring

Figure 7 shows an embodiment of a drop/insert node or a supervision node used in the centralized control type ring network, which is constructed by a receiving unit 1 and a transmitting unit 3 for the working, line W, a receiving unit 4 and a transmitting unit 2 for the protection line P, overhead processing units 5 and 6, and a data drop/insert/ pass processing unit 7. The receiving units 1 and 4 are respectively constructed by light receiving units 11 and 41 connected to the working line W and the protection line P for converting light input signals into electrical signals, overhead dropping units 12 and 42 for dropping the overhead from the electrical signals to provide to the overhead processing units 5 and 6, and main signal processing units 13 and 43 for processing main signals other than the overheads and for sending the dropped and passed signals to the data drop/insert/pass processing unit 7. The transmitting units 2 and 3 are respectively constructed by main signal processing units 21 and 31 for processing the inserted and passed signals from the data drop/insert/pass processing unit 7, overhead inserting units 22 and 32 for inserting overheads from the overhead processing units 5 and 6 into the inserted and passed signals, and light transmitting units 23 and 33 for converting the thus generated electric signals into light signals and for transmitting them to the protection line P and the working line W, respectively. Note, the process relating to the overhead is carried out by the overhead processing units 5 and 6.

① An Example of a Cut Causing a Fault in the Working line W (see Fig. 8)

For the case when a fault is caused by a cut in the working line W of an optical fiber between the node A and node B occurs, the fault recovery system of the present invention will be described.

Referring to Fig. 8A, the node A, which has detected, by its light receiving unit 11, the input fault of the working line W such as a missing clock signal, loads the node identification number of the node A on the F1 byte and transmits the F1 byte. In this case, a fault data F1(A,-,0) and a loopback request K(W→P) are transmitted from the node A to the downstream side of the working line W through the communication between the overhead processing units 5 and 6, and fault data F1(A,-,0) is also transmitted from the node A to the downstream side of the protection line P through the communication between the overhead processing units 5 and 6. The loopback request K(W→P) is formed by rewriting the K1 or K2 byte in the STM-1 frame format. Note that, the loopback request K is, as described with reference to Fig. 1, internationally standardized. Therefore, when the K1 or K2 byte is used for the loopback request instead of using the S bit in the F1 byte, it conforms with the international standardization. By contrast, when the S bit (b2 in the F1 byte) is used for the loopback request, the loopback request can also be executed, and therefore, the loopback request K is not always used.

Since the node D is normal, it passes the F1 byte transmitted from the node A through the working line W, and the nodes B and C pass the F1 byte transmitted from the node A through the protction line P. In each of the nodes D, B, and C, the input signal itself is passed through the route in which the receiving unit 1, the data drop/insert/pass processing unit 7, and the transmitting unit 3 are connected.

Referring to Fig. 8B, the supervision node SV detects in its overhead processing units 5 and 6 the fault data (F1 byte plus K byte or F1 byte) transmitted from the node A through the working line W and the protection line P, analyzes the new situation including the fault data to determine the node A located imediately downstream of the fault position and closest to the supervision node SV, and transmits, to the protection line P, a loopback request (instruction) K(W→K) and fault data F1-(A,A,1) requiring execution of a loopback at the node A and a fault data F1(A,A,1). The supervision node SV also transmits a loopback request K-

BNSDOCID: <EP 0456206A2 I >

(W→P) and a fault data F1(B,B,1) requiring a loopback be effected at the node B immediately upstream of the fault position and closest to the supervision node SV. The node A detects the loopback request from the supervision node SV, carries out this loopback, and then rerturns a loopback response K(W→P) and F1(A,A,1) through the working line W to the supervision node SV. The node B also carries out the loopback, and then returns a response K(W→P) and F1(B,B,1) to the supervision node SV through the protection line P.

Referring to Fig. 8C, the supervision node SV receives the loopback responses from the nodes A and B, and acknowleges that a fault recovery route (loopback route) has been completed. After completion of the fault recovery, the supervision node SV resets the F1 byte to be all zeroes and transmits F1(-,-,0) to the working line W and the protection line P. Accordingly, in a stationary state where no fault occurs, the supervision node SV detects the F1(A,-,0) from the working line W and F1(-,B,0) from the protection line P.

② An Example of Cuts Causing Faults in the Working Line W and the Protection Line P (see Figs. 9A to 9C)

For the case when faultscaused by cuts in both the working line W and the protection line P between the node A and the node B occurs, the fault recovery system of the present invention is described.

Referring to Fig. 9A, the node A, which has detected an input fault on the working line W, transmits F1(A,-,0) and a loopback request K(W→P) to the downstream side of the working line W, and transmits F1(A,-,0) to the downstream side of the protection line P; and the node B, which has detected the input fault on the protection line P, transmits F1(-,B,0) to the downstream of the protection line P.

In this case, even if the F1(A,-,0) is transmitted from the node A to the downstream side of the protection line P, it does not reach the node B because the optical fiber of the protection line P between the node A and the node B is cut. Similarly, even when F1(-,B,0) is transmitted from the node B to the downstream of the working line W, F1(-,B,0) on the working line W does not reach the node A because of the fiber cut (cut in W). Since the node D is normal, it passes the F1 byte transmitted from the node A through the working line W, and the node C passes the F1 byte transmitted from the node B through the protection line P.

Referring to Fig. 9B, the supervison node SV detects the loopback request K(W→P) and the fault data F1(A,-,0) transmitted from the node A through the working line W, detects the fault data F1(-,B,0) transmitted from the node B through the protection line P, analyzes this new situation including the fault data to determine the position of the fault, transmits a loopback request K(W→P) requiring to loopback at the node A and F1(A,A,1) to the downstream side of the protection line P, and transmits a loopback request K(W→P) requiring a loopback at the node B and F1(B,B,1) to the downstream side of the working line W.

The node A detects the loopback request from the supervision node SV through the protection line P, carries out this loopback operation, and then returns a response K(W→P) and F1(A,A,1). The node B also carries out the loopback operation and then returns a response K(W→P) and F1(B,B,1) to the supervision node SV.

Referring to Fig. 9C, the supervision node SV acknowledges the completion of a fault recovery route (loopback route) by receiving the loopback responses from the nodes A and B. After the completion of the fault recovery, the supervision node Sv resets the F1 bytes to be all zeroes and transmits them to the working line W and the protection line P. Accordingly, in the stationary state in which there is no fault in the ring network, the supervision node SV detects the F1(A,-,0) from the working line W and the F1(-,B,0) from the protection line P.

③ An Example of Plural Faults (see Figs. 10A to 10C)

For the case when both the working line W and the protection line P between the nodes A and B are cut and when the protection line P is cut between the nodes D and A, the fault recovery system of the present invention will be described.

Referring to Fig. 10A, similar to the above example shown in Fig. 9A, the node A transmits a loopback request K(W→P) and F1(A,A,0) through the downstream side of the working line W to the supervision node SV, and the node B transmits fault data F1(-,B,0) through the downstream side of the protection line P to the supervision node SV.

Referring to Fig. 10B, the supervision node SV analyzes the new situation including the fault state to determine the position of the fault. Then the supervision node SV transmits a loopback request K(W→P) requiring a loopback at the node D and F1(D,D,1) to the downstream side of the protection line P, and transmits a loopback request K(W→P) requiring to loopback at the node B and F1(B,B,1) to the downstream side of the working line W. Then, the node D detects the loopback request from the supervision node SV, carries out this loopback operation, and returns a response K-(W→P) and F1(D,D,1) to the supervision node SV. The node B also detects the loopback request from

BNSDOCID <EP 0456206A2 I >

the supervision node SV, carries out this loopback operation, and returns a response K(W→P) and F1-(B,B,1) to the supervision node SV.

Referring to Fig. 10C, the supervision node SV acknowledges the completion of a fault recovery route (loopback route) by receiving the loopback responses from the nodes D and B. After the completion of the fault recovery, the supervision node SV resets the F1 bytes to be all zeroes and transmits them to the working line W and the protection line P. Accordingly, in a stationary state in which there is no fault, the supervision node SV detects F1(D,-,0) from the working line W and F1(-,B,0) from the protection line P.

Distributed Control Type Ring

In this distributed control type ring network, there is no supervision node, and the respective drop/insert nodes are placed in aan equal relation to each other. In this case also, the example of the construction shown in Fig. 7 can be applied, and the difference from the centralized control type ring is that, since there is no supervision node, the F1 bytes are not reset by the supervision node, and the others are processed in a similar way to those in the centralized control type ring.

① An Example of Cuts Causing Faults in the Working Line W and the Protection Line P (see Figs. 11A to 11C)

For the case when both the working line W and the protection line P between the nodes A and B are cut, the fault recovery system of the present invention will be described.

Referring to Fig. 11A, the node A which has detected a fault on the working line W transmits F1(A,*,0) and a loopback request K(W→P) to the downstream side of the working line W, and transmits F1(A,*,0) to the downstream side of the protection line P. In this case, in the initial state of the fault, there is a possibility that the node A may not know about the fault on the protection line P because the fault on the protection line P is at the output side of the node A, so that the node A may transmit F1(A,*,0) to the downstreams of the working line W and the protection line P. The node A, however, will know about the fault on the protection line P from the later received fault data from the node B thorugh the protection line P. After the node A acknowleges the fault on the protection line P, the node A transmits F1(A,B,-) to the downstream sides of the working line W and the protection line P. In this case, * represents a time dependent parameter. Note, in this case also, if the K bytes of the loopback request are not used as mentioned before, a loopback request to an other node is realized by changing the "0" in the F1(A, * , 0) to "1".

The node B which has detected a fault on the protection line P transmits F1(*,B,0) of the F1 bytes containing the node identification number of the node B, to the downstream sides of both the working line W and the protection line P. In this case, the F1(A,*,0) on the protection line P does not reach the node B because of the cut fiber (P cut), and the F1(* ,B,0) on the working line W does not reach the node A because the cut fiber (W cut). The nodes D, E, and C pass the F1 byte transmitted from the node A through the working line W, and the nodes C, E, and D pass the F1 byte transmitted from the node B through the protection line P.

Referring to Fig. 11B, the node B detects the loopback request K(W →P) and the fault data including the F1(A,*,0) transmitted from the node A through the working line W. By analyzing the fault data F1(A,*,0), the node B recognizes that its own node B is placed immediately upstream of he fault position, i.e., just before the node A which has transmitted the fault data. This recognition is possible because all of the nodes are provided with their own node identification numbers in advance. Accordingly, the fault on the protection line P between the nodes A and B is determined so that a loopback operation is executed at the node B. The node B then transmits a loopback response K-(W→P) and F1(A,B,0) through the protection line P to the node A.

Referring to Fig. 11C, the node A receives the loopback response K(W →P) and the F1(A,B,0) from the node B through the protection line P so that it determines the position of the fault on the working line W between the nodes A and B. Then the node A executes a loopback operation from the protection line P to the working line W. In this way, it is recognized that the fault recovery route (loopback route) has been completed, and, in a stationary state after the fault recovery completion, the F1(A,B,0) is transmitted through the working line W and the protection line P.

③ An Example of Plural Faults (see Figs. 12A to 12C)

For the case when faults occur due to cut in both the working line W and the protection line P between the node A and the node B, and a cut in the working line W between the nodes B and C, the fault recovery system of the present inveniton will be described.

Referring to Fig. 12A, the node A transmits a loopback request K(W→P) and F1(A,*,0) through the downstream side of the working line W to the node C, and the node B transmits F1(B,B,0)

BNSDOCID: <EP 0456206A2 I >

through the downstream side of the protection line P to the node A since both the working line W and the protection line P are in their input fault states.

Referring to Fig. 12B, the node C detects the fault on the working line W between the node C and the node B based on the fault data F1(B,B,0) transmitted from the node B through the protection line P and the fault data F1(A, ✳ ,0) from the node A. The node C analyzes this new situation, executes a loopback operation, and transmits a loopback response k(W→P) and F1(A,C,0) to the node A through the protection line P.

Referring to Fig. 12C, the node A, which receives this loopback response K(W→P) and F1-(A,C,0) from the node C, determines the fault on the working line W between the nodes A and B. Then, the node A executes the loopback operation at the node A to complete the fault recovery route (loopback route). In the stationary state after completion of the fault recovery completion, F1(A,C,0) is transmitted through the working line W and the protection line P.

Hybrid Ring

In this case also, there is no supervision node so that the respective nodes have an equal relation to each other.

Figure 13 schematically shows the construction of each node. In the figure, the same references as those in Fig. 7 represent the same parts, and, also included are a selector 8 for selecting data to be dropped or passed from or the receiving unit 1 or 4 to the data drop/insert/pass processing unit 7, a distributing unit 9 for distributing the inserted or passed data from the data drop/insert/pass processing unit 7 to the transmitting units 2 or 3, and a control circuit 10 for controlling the selector 8 . The control circuit 10 selects a normal signal from the signals received by the receiving units 1 and 4. When both are normal, the control circuit 10 selects the receiving signal on the working line W. However, the selector 8 is controlled only when the drop/insert mode is effected for the corresponsing channel chich needs to be dropped or inserted. In the case of another channel, namely, when the channel is not to be dropped or inserted, the receiving units 1 and 4 and the transmitting units 3 and 2 are connected straight through as illustrated in the figure by a dotted line. Note, the discrimination of whether or not the signal is normal can be carried out based on a cut in the input signal or by a lack of frame synchronization. It may also be discriminated by an alarm indication or a pointer indicating an abnormal in H1 and H2 pointer bytes included in the overhead of the STM frame which is processed by the overhead processing units 5 and 6.

Examples of faults in the hybrid ring using the node having such a construction as described above, are illustrated in Fig. 14.

(1) An Example When the Working Line W Between the Nodes A and B is Cut

In this case, as the F1 byte of the fault data, the F1 byte F1(A,-,0) which is the same as the one shown in Figs. 8A to 8C is output from the nodes A and B (time t1). In the node A, since an input fault occurs on the working line W, only the received signal transmitted from the node D through the protection line P is determined as normal and is received byte by byte. Also, in the node B, the received signal from the node C through the working line W and the received signal from the node A through the protection line P are received as normal and are received byte by byte. Therefore, the control circuit 10 in the node B switches the selector 8 to receive with priority the received signal from the working line W. Note, the other nodes C, D, and E only pass the received signals on the working line W and the protection line P.

After this, even at a time t2 when some time has passed from the time t1, the state of the F1 byte is quite unchanged.

Thus, by the working line W and the protection line P, the node A and the node B communicate with each other without loopback.

Also, since the overhead is used in this case also, the fault evaluation (of a cut in the working line W between the nodes A and B) can be executed in a way similar to that mentioned above in the nodes A and B.

(2) An Example When Both the Working Line W and the Protection Line P Between the Nodes A and B are cut

In this case, the F1 bytes F1(A,-,0) and F1(-,B,0) as the fault data, which are the same F1 byte as shown in Figs. 9A to 9C and Figs. 11A to 11C, are output from the nodes A and B, respectively (time t1). The node A receives only the receiving signal transmitted from the node D through the protection line P as a normal signal because the input fault occurs on the working line W between the nodes A and B, and the node B receives only the receiving signal transmitted from the node C through the working line W as a normal signal because the input fault occurs on the protection line P between the nodes A and B.

After this, at a time t2, since both the node A and the node B respectively know about the the faults on the protection line P and the working line W, the F1 bytes become F1(A,B,0) as illustrated in Fig. 14 (2).

BNSDOCID: <EP 0456206A2 I >

Thus, by the working line W and the protection line P, the node A and the node B communicate with each other without loopback.

Also, by the use of the usdbyte in this case also, the fault evaluation (of a cut in the working line W between the nodes A and B) can be executed in the nodes A and B in a way similar to that mentioned before.

(3) An Example When Both the Working Line W and the Protection Line P Between the Nodes A and B are Cut and the Working line W between the Nodes B and C is Cut

In this case, the F1 bytes F1(A,-,0) and F1-(B,B,0) as the fault data, which are the same F1 bytes as shown in Figs. 10A to 10C and Figs. 12A to 12C, flow through the working line W and the srotection line P (time t1). The node A receives only the receiving signal transmitted from the node D through the protection line P as a normal signal because the input fault occurs on the working line W between the nodes A and B, the node B cannot receive a signal because the input faults occur on both the working line W and the protection line P, and the node C receives with priority the receiving signal transmitted from the node E through the working line W as a normal signal.

At a time t2 after a certain amount of time has passed, the node A detects the input fault of the node B so that the F1 byte F1(A,B,0) as illustrated in the figure flows through the working line W.

Thus, through the working line W and the protection line P, the nodes A and C communicate with each other without loopback.

In this case also, since the overhead is used, the fault evaluation (of a cut in the working and protection lines between the nodes A and B, and a cut in the working line W between the nodes B and C) can be executed in the nodes A, B, and C in a way similar to that mentioned before.

Thus, in the hybrid ring also, by applying the overhead, the ability to respond to a fault in a ring (especially the case of a plurality of faults or a catastrophic fault) can be increased.

As described above, according to the fault recovery system of a ring network relating to the present invention, by utilizing a predetermined user byte in the overhead of the STM frame used in the synchronous transport module transmitting system, an input fault detected in any node in a centralized control type ring, distributed control type ring, or hybrid ring is transferred to an other node, whereby the supervision node or the drop/insert node detects the position of the fault to execute a loopback operation or a hybrid process. Therefore, since no protocol is used in the fault recovery process, the fault can be recovered in a short time.

Reference signs in the claims are intended for better understanding and shall not limit the scope.

Claims

1. A fault recovery system of a centralized control type ring network based on a synchronous transport module transmission system, characterized in that:

said ring network comprises:

optical fiber transmission lines including a working line (W) and a protection line (P) running in opposite directions to each other;

a plurality of drop/insert nodes (A, B, C, and D) connected to each other through said optical fiber transmission lines (P and W); and

a supervision node (SV), connected through said optical fiber transmission lines (P and W) to said drop/insert nodes (A, B, C, and D);

each of said drop/insert nodes having:

input fault detecting means (11,33) for detecting an input fault on the working line (W) or the protection line (P);

fault data writing means (22,32) for writing, when said input fault is detected by said input fault detecting means (11,33), fault data (F1-(#n,#k,S)) in a predetermined user byte (UB) in an overhead of a frame flowing through both of the working line (W) and the protection line (P); and

user byte passing means (7) for passing said user byte (UB) as is through said node, when an input fault is not detected by said input fault detecting means (11,33); and

said supervision node (SV) having:

fault data detecting means (12,42) for detecting the fault data in said user byte (UB) transmitted from the node which has detected said input fault through the downstream sides of the working line (W) and the protection line (P) of said node which has detected said input fault;

fault position determining means (5,6) for determining, based on said fault data detected by said fault data detecting means (12,42), a node which has detected said input fault;

writing means (5,6) for writing, into said user bytes (UB), loopback requests (LBR) for requesting nodes located immediately downstream and upstream of the fault position and closest to said supervision node, to execute loopback operations; and

sending means (7) for sending said loopback requests (LBR) through said working line (W) and said protection line (P) to said nodes located downstream and upstream of the fault position;

BNSDOCID: <EP 0456206A2 I >

whereby said nodes located immediately downstream and upstream of the fault position and closest to said supervision node (SV) execute loopback operations to recover the fault.

2. A fault recovery system of a ring network as claimed in claim 1, characterized in that said synchronous transport module transmission system is a system according to the recomendation of CCITT G.707, 708, and 709.

3. A fault recovery system of a ring network as claimed in claim 1, wherein said fault data (F1-(#n,#k,S)) includes a node identification number (#n, #K) for identifying the node which has detected the input fault.

4. A fault recovery system of a ring network as claimed in claim 1, wherein said fault data (F1-(#n,#k,S)) includes fault line information indicating whether said input fault has occurred on said working line (W) or on said protection line (P).

5. A fault recovery system of a ring network as claimed in claim 4, wherein said fault data (F1-(#n,#k,S) includes fault reporting information (S = "0").

6. A fault recovery system of a ring network as claimed in claim 4, wherein said loopback requests (LBR) are formed by rewriting said fault data (F1(#n,#k,S)) to include a node identification number ((#n,#n), (#k,#k)) of a node at which the loopback should be executed, and loopback request information (S = "1").

7. A fault recovery system of a ring network as claimed in claim 1, wherein said loopback requests (LBR) are formed by using another byte other than said predetermined user byte in said overhead of said frame.

8. A fault recovery system of a ring network as claimed in claim 7, wherein said other byte in said overhead of said frame is the K1 byte or the K2 byte according to the recommendation of CCITT G.707, 708, and 709.

9. A fault recovery system of a ring network as claimed in claim 1, wherein said writing means (5,6) has rewriting means for rewriting said fault data (F1(#n,#k,S)) transmitted through said working line (W) into a first loopback request (F1(A,A,1)) and for rewriting said fault data transmitted through said protection line (P) into a second loopback request (F1(B,B,1)), and said sending means (5,6) has means for sending said first loopback request (F1(A,A,1)) through said protection line (P) and for sending said second loopback request (F1(B,B,1)) to said working line (W).

10. A fault recovery system of a ring network as claimed in claim 1, wherein said ring network is a bidirectional ring network comprising a pair of clockwise and counterclockwise working lines (W) and a pair of counterclockwise and clockwise protection lines (P).

11. A fault recovery system of a ring network as claimed in claim 10, comprising a plurality of pairs of said working lines (W) and a single pair of said protection lines (P).

12. A fault recovery system of a distributed control type ring network based on a synchronous transport module transmission system, characterized in that:

said ring network comprises:

optical fiber transmission lines including a working line (W) and a protection line (P) running in opposite directions to each other; and

a plurality of drop/insert nodes (A, B, C, D and E) connected to each other through said optical fiber transmission lines (P and W);

each of said drop/insert nodes having:

input fault detecting means (11,33) for detecting an input fault on the working line (W) or the protection line (P);

fault data and loopback request writing means (22,32) for writing, when said input fault is detected by said input fault detecting means (11,33), fault data (F1(#n,#k,S)) and a loopback request in a predetermined user byte (UB) in an overhead of a frame flowing through both the working line (W) and the protection line (P);

loopback executing means (5,6) for executing, based on said fault data detected by said fault data detecting means (12,42), a loopback when said node is located immediately upstream of said input fault and adjacent to a node which has not detected an input fault;

said node executing said loopback returning, in response to said loopback request, a loopback response by the use of said predetermined user byte (UB) to said node which has detected said input fault.

13. A fault recovery system of a ring network as claimed in claim 12, characterized in that said synchronous transport module transmission system is the system according to the recomendation of CCITT G.707, 708, and 709.

BNSDOCID: <EP 0456206A2 I >

14. A fault recovery system of a ring network as claimed in claim 12, wherein said fault data (F1(#n,#k,S)) includes a node identification number (#n,#K) for identifying the node which has detected the input fault.

15. A fault recovery system of a ring network as claimed in claim 14, wherein said fault data (F1(#n,#k,S)) includes fault line information indicating whether said input fault has occurred on said working line (W) or on said protection line (P).

16. A fault recovery system of a ring network as claimed in claim 15, wherein said fault data (F1(#n,#k,S)) includes fault reporting information (S = "0").

17. A fault recovery system of a ring network as claimed in claim 16, wherein said loopback request (LBR) is formed by rewriting said fault reporting information in said fault data (F1-(#n,#k,S = "1")).

18. A fault recovery system of a ring network as claimed in claim 12, wherein said loopback request (LBR) is formed by using another byte (K1 or K2) other than said predetermined user byte (UB) in said overhead of said frame.

19. A fault recovery system of a ring network as claimed in claim 18, wherein said other byte in said overhead of said frame is the K1 byte or the K2 byte according to the recommendation of CCITT G.707, 708, and 709.

20. A fault recovery system of a ring network as claimed in claim 12, wherein said ring network is a bidirectional ring network comprising a pair of clockwise and counterclockwise working lines (W) and a pair of counterclockwise and clockwise protection lines (P).

21. A fault recovery system of a ring network as claimed in claim 20, comprising a plurality of pairs of said working lines (W) and a single pair of said protection lines (P).

22. A fault recovery system of a hybrid type ring network based on a synchronous transport module transmission system, characterized in that:

said ring network comprises:

optical fiber transmission lines including a working line (W) and a protection line (P) running in opposite directions to each other; and

a plurality of drop/insert nodes (A, B, C, and D) connected to each other through said optical fiber transmission lines (P and W);

each of said drop/insert nodes comprising selecting means (8,10) for dropping the input signal from said protection line (P) when the input signal from said working line (W) is faulty, for dropping the input signal from said working line (W) when when the input signal from said protection line (P) is faulty, and for dropping the input signal from said working line (W) when both are normal, and passing the signal as is when the signal is not to be dropped.

23. A fault recovery system of a hybrid type ring network as claimed in claim 22, wherein:

each of said drop/insert nodes has:

input fault detecting means (11,33) for detecting an input fault on the working line (W) or the protection line (P);

fault data writing means (22,32) for writing, when said input fault is detected by said input fault detecting means (11,33), fault data (F1-(#n,#k,S)) in a predetermined user byte (UB) in an overhead of a frame flowing through both the working line (W) and the protection line (P); and

user byte passing means (7) for passing, when an input fault is not detected by said input fault detecting means (11,33), said user byte (UB) as is through said node.

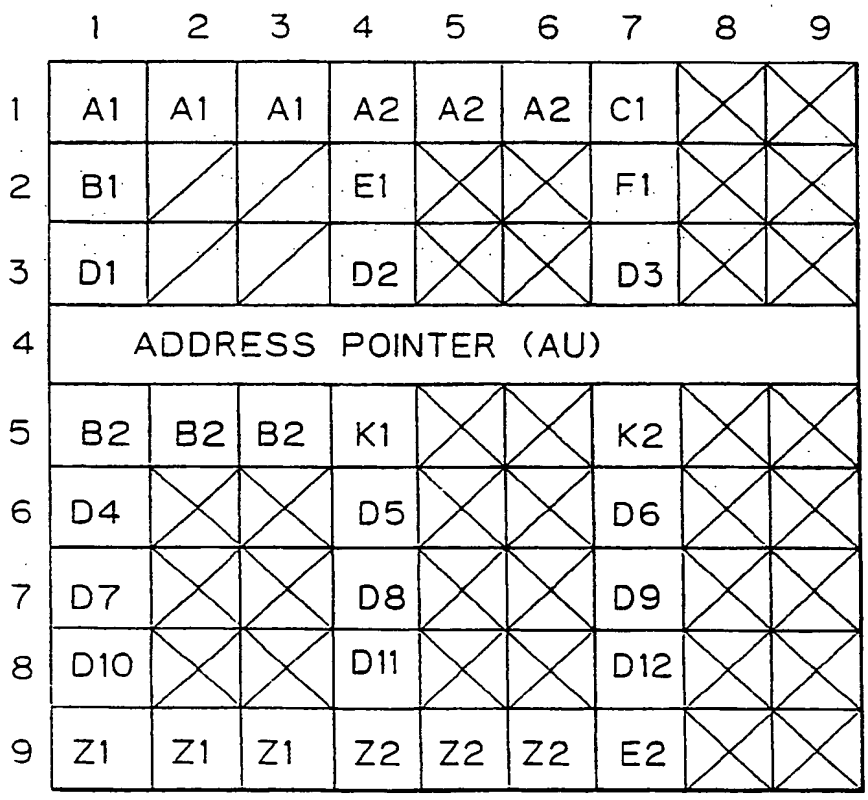
24. A fault recovery system of a hybrid ring network as claimed in claim 23, characterized in that said synchronous transport module transmission system is a system according to the recomendation of CCITT G.707, 708, and 709.

25. A fault recovery system of a hybrid ring network as claimed in claim 23, wherein said fault data (F1(#n,#k,S)) includes a node identification number (#n,#K) for identifying the node which has detected the input fault.

26. A fault recovery system of a hybrid ring network as claimed in claim 23, wherein said fault data (F1(#n,#k,S)) includes fault line information indicating whether said input fault has occurred on said working line (W) or on said protection line (P).

BNSDOCID: <EP 0456206A2 I >

Fig. 1



BNSDOCID <EP 0456206A2 >

Fig. 2A

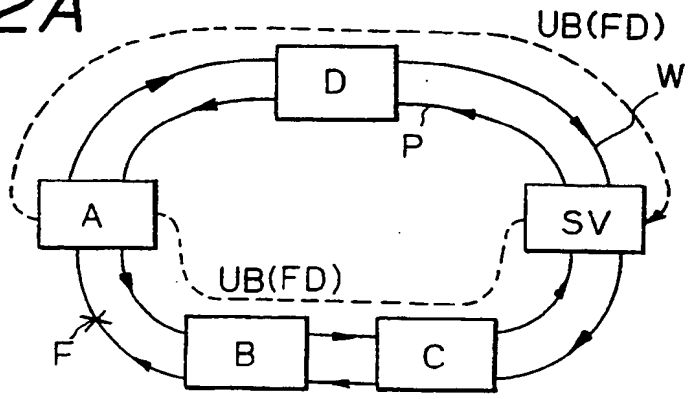


Fig. 2B

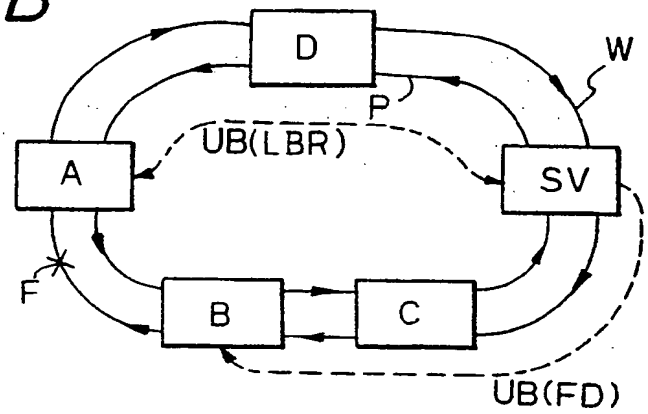
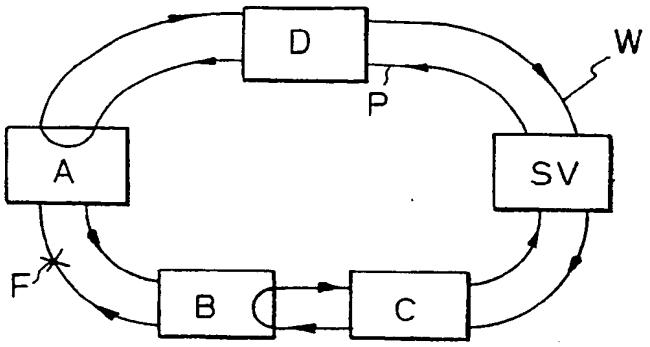


Fig. 2C



BNSDOCID: <EP 0456206A2 I >

Fig. 3A

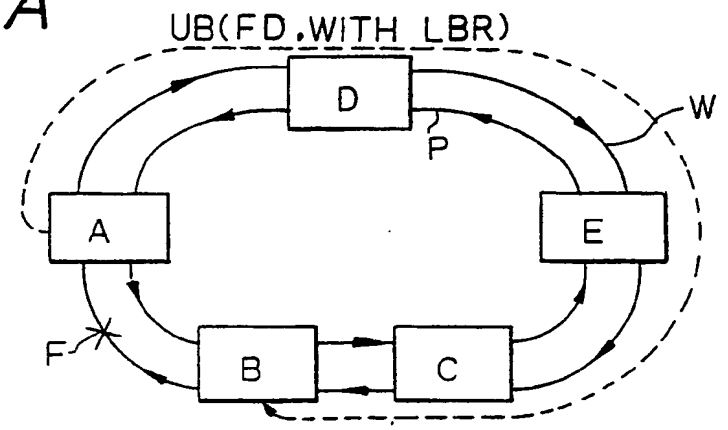


Fig. 3B

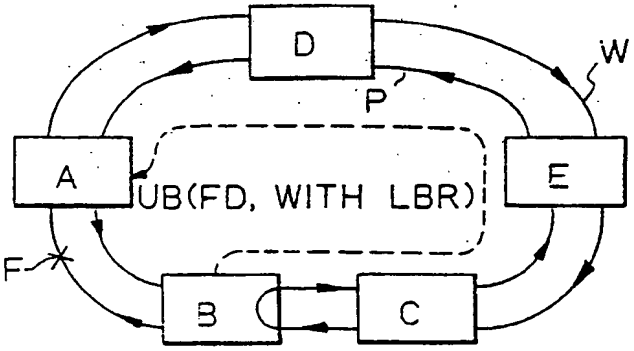
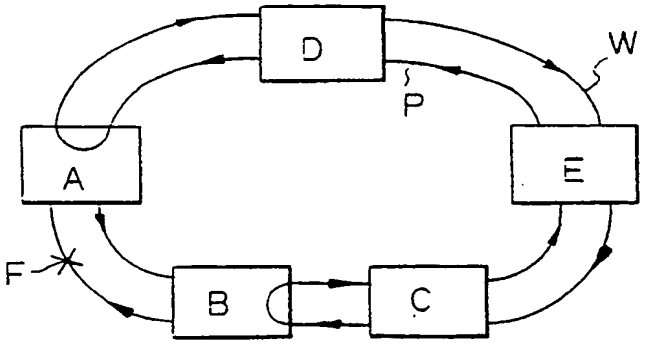


Fig. 3C



BNSDOCID: <EP 0456206A2 >

Fig. 4A

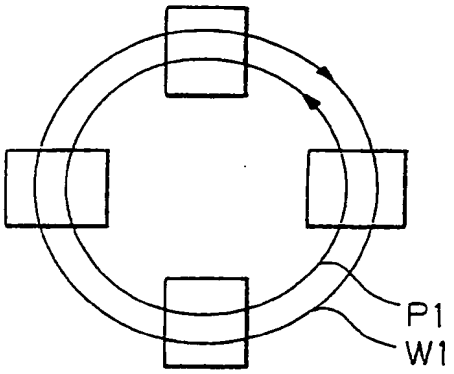


Fig. 4B

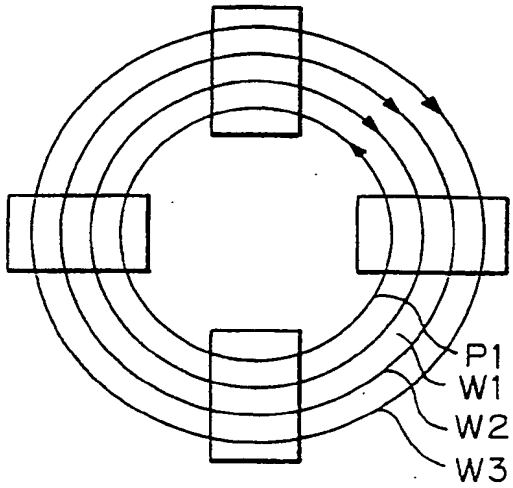


Fig. 4C

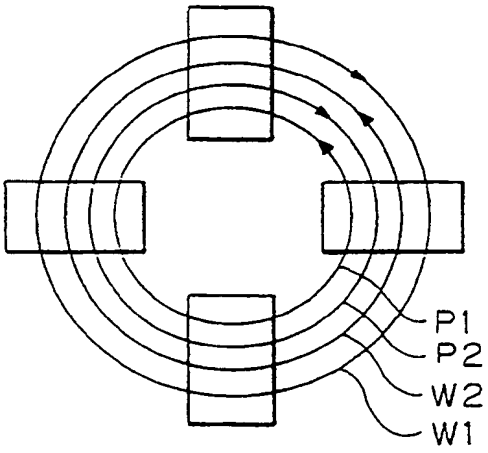
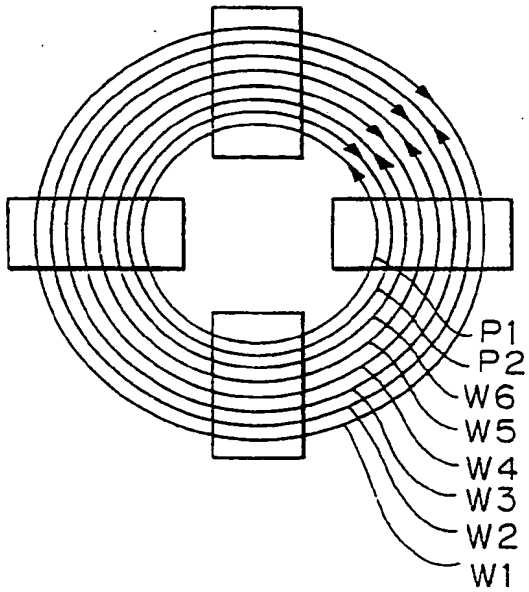
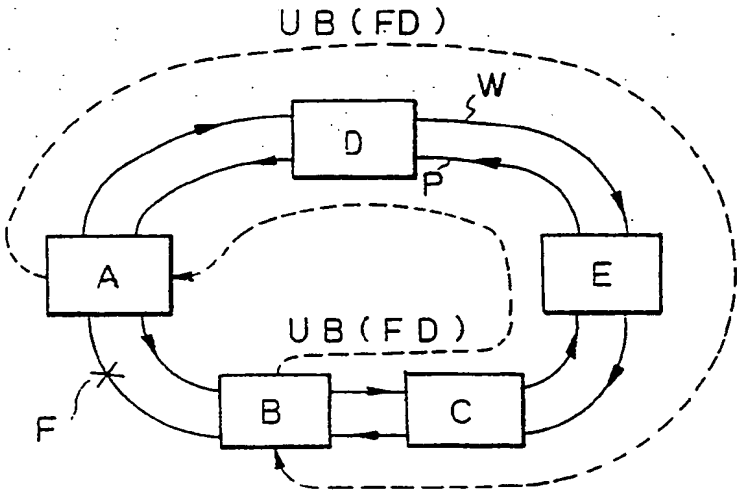


Fig. 4D



BNSDOCID: <EP 0456206A2 I >

Fig. 5



DEFINITION OF THE F1 BYTE

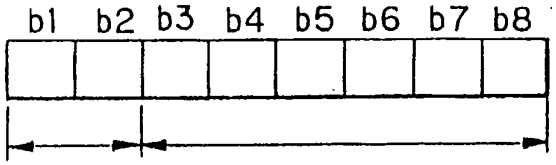


Fig. 6A

b1 : "0" MEANS FAILURE-DETECTED NODE IDENTIFIER (NODE ID) ON WORKING LINE.
"1" MEANS FAILURE-DETECTED NODE IDENTIFIER (NODE ID) ON PROTECTION LINE.

b2 : "0" MEANS FAILURE REPORTING
"1" MEANS THE SWITCH REQUEST AT THE NODE DESIGNATED WITH NODE ID

Fig. 6B

FRAME STRUCTURE OF THE F1 BYTE

SUCCESSIVE TWO OF THE F1 BYTES CONSTITUTES A FRAME.

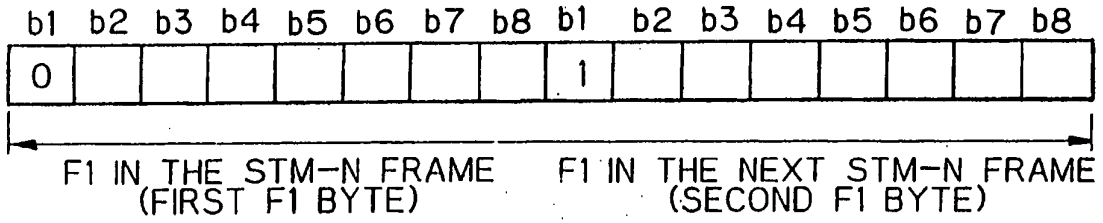
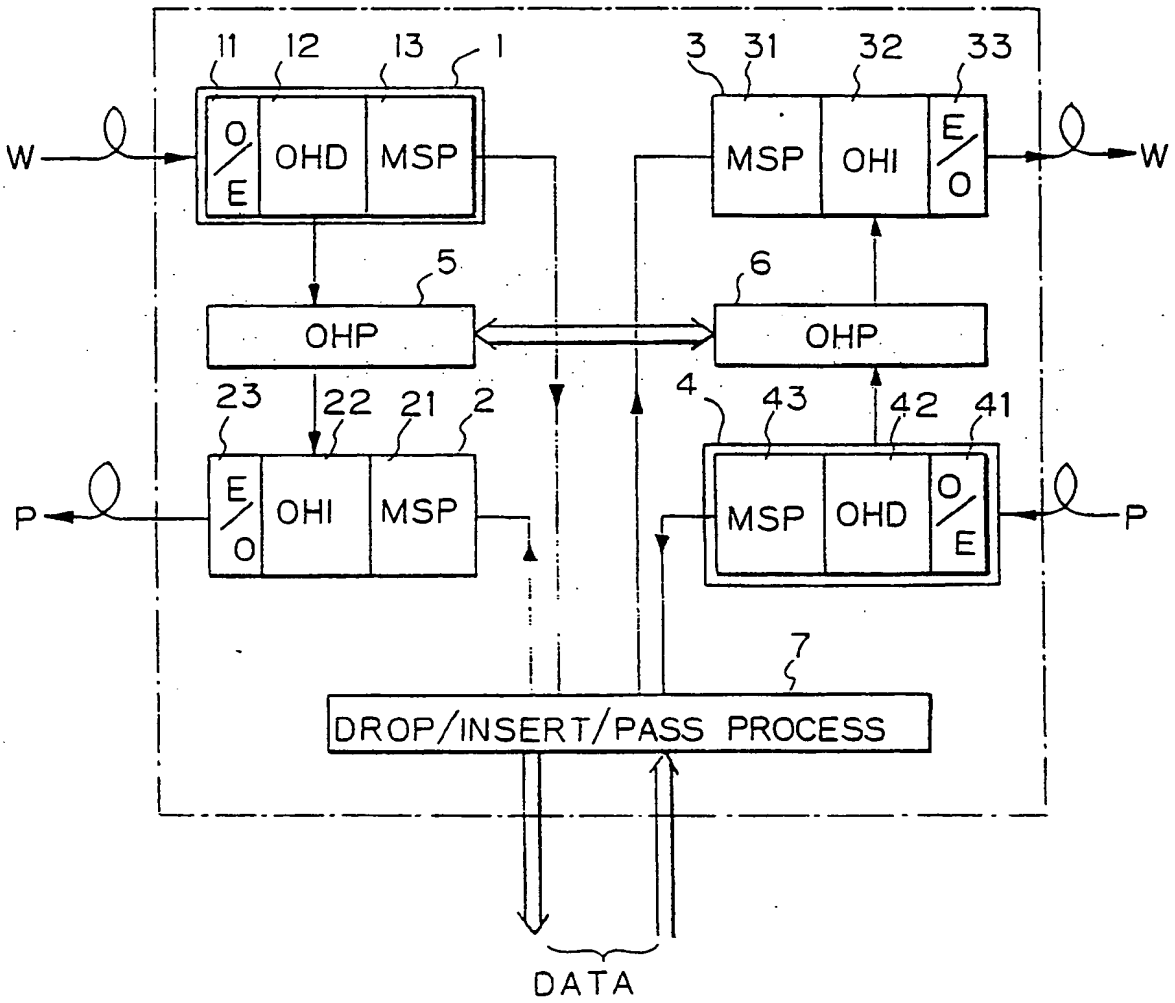


Fig. 6C

STATE OF THE ABOVE FIGURE	FRAME OF THE F1 BYTES	
	1st F1	2nd F1
(1) THE NOMAL STATE	00000000	10000000
(2)	00000000	10000011
(3)	00000001	10000000

EP 0 456 206 A2

Fig. 7



BNSDOCID: <EP 0456206A2 I >

Fig. 8A

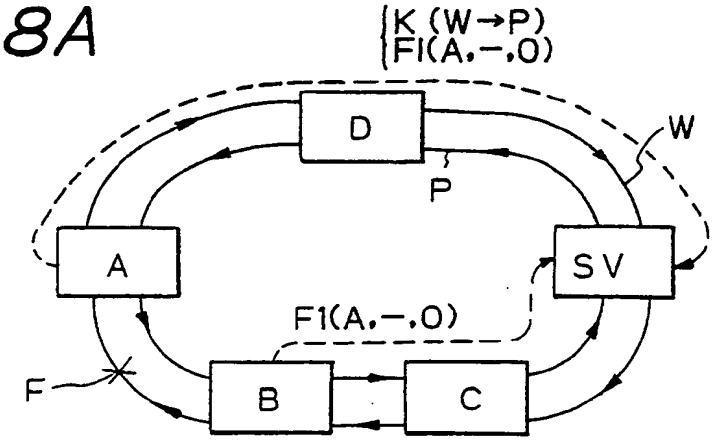


Fig. 8B

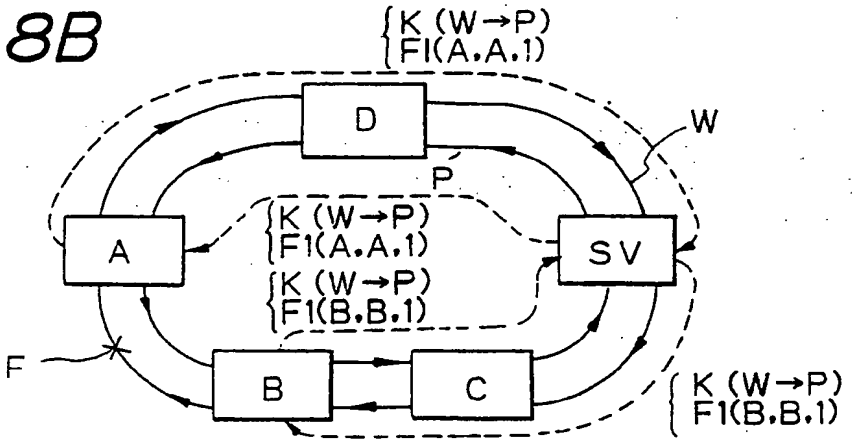
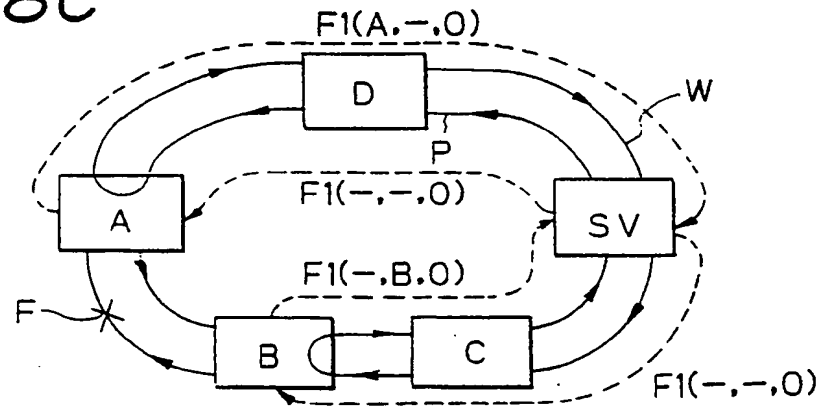


Fig. 8C



BNSDOCID: <EP 0456206A2 I >

Fig. 9A

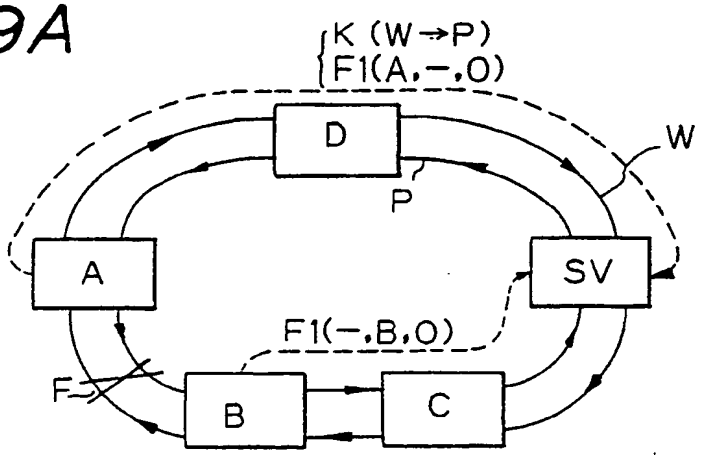


Fig. 9B

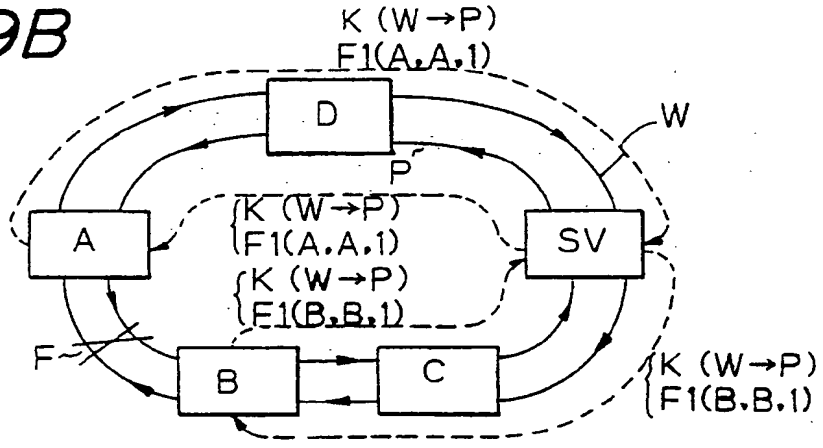
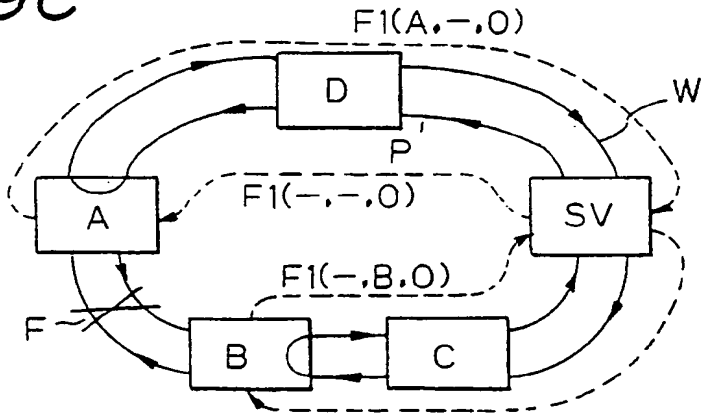


Fig. 9C



BNSDOCID: <EP 0456206A2 I >

Fig. 10A

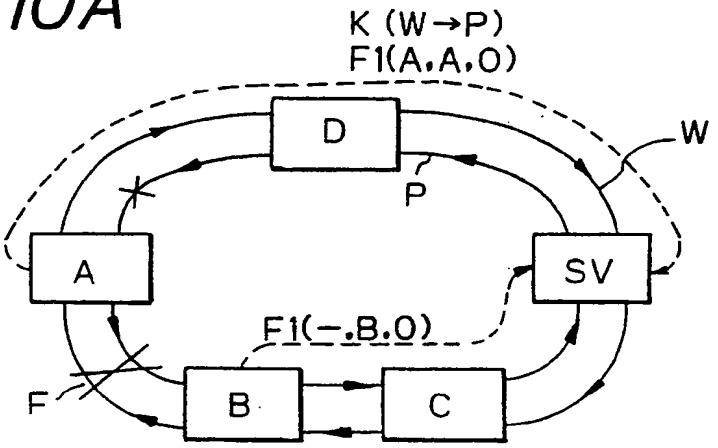


Fig. 10B

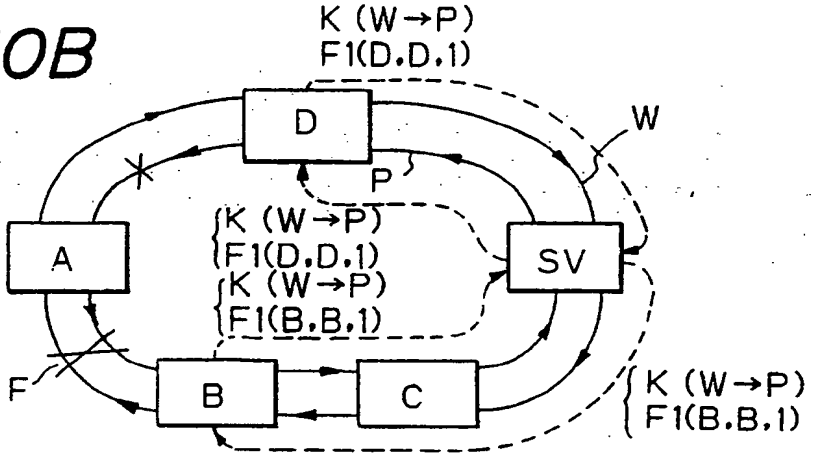
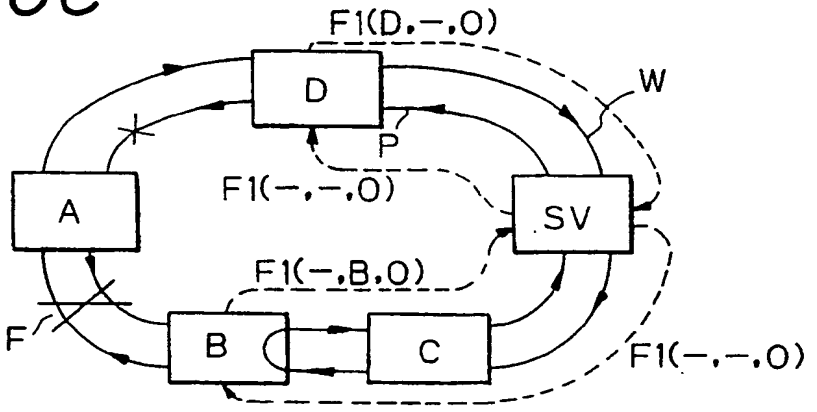


Fig. 10C



BNSDOCID: <EP 0456206A2 I >

Fig. 11A

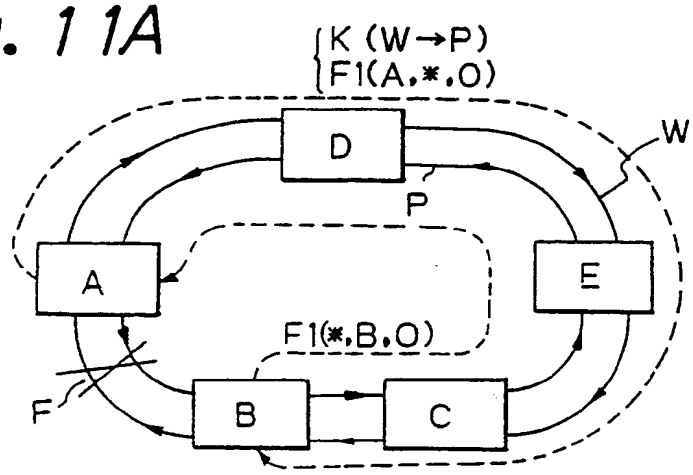


Fig. 11B

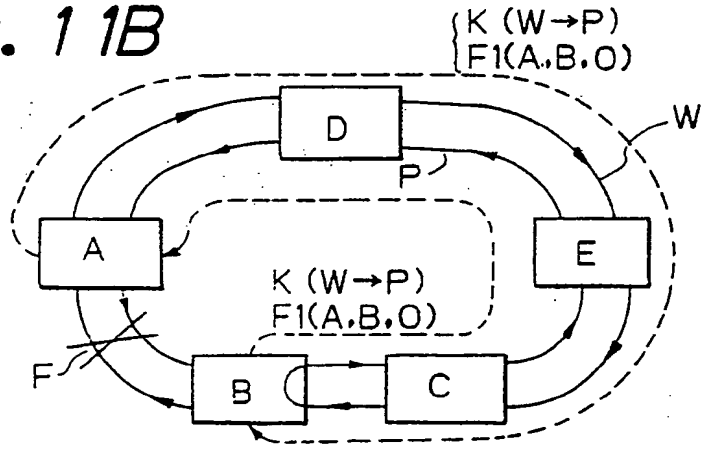
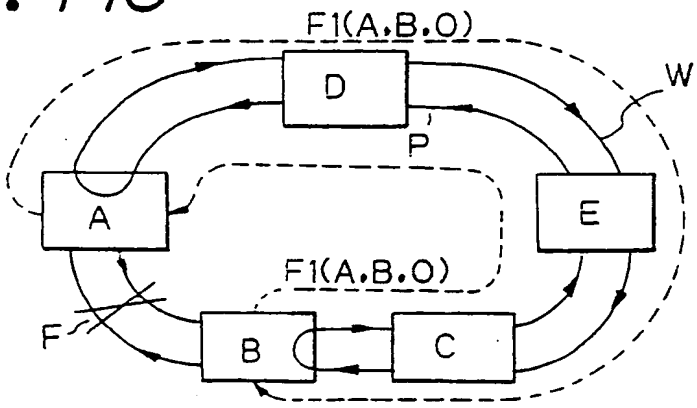


Fig. 11C



BNSDOCID: <EP 0456206A2 I >

Fig. 12A

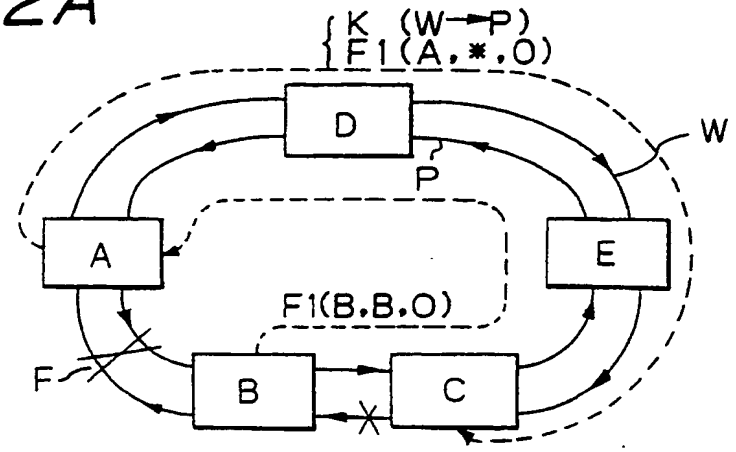


Fig. 12B

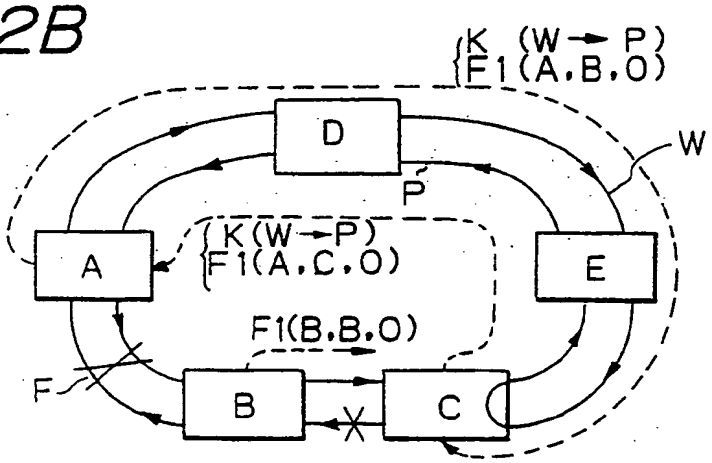
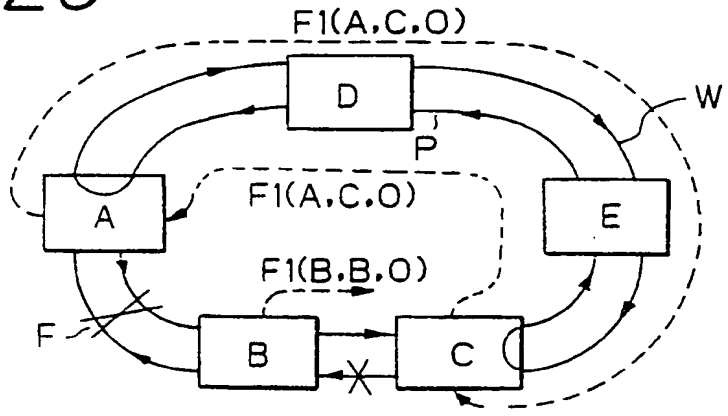
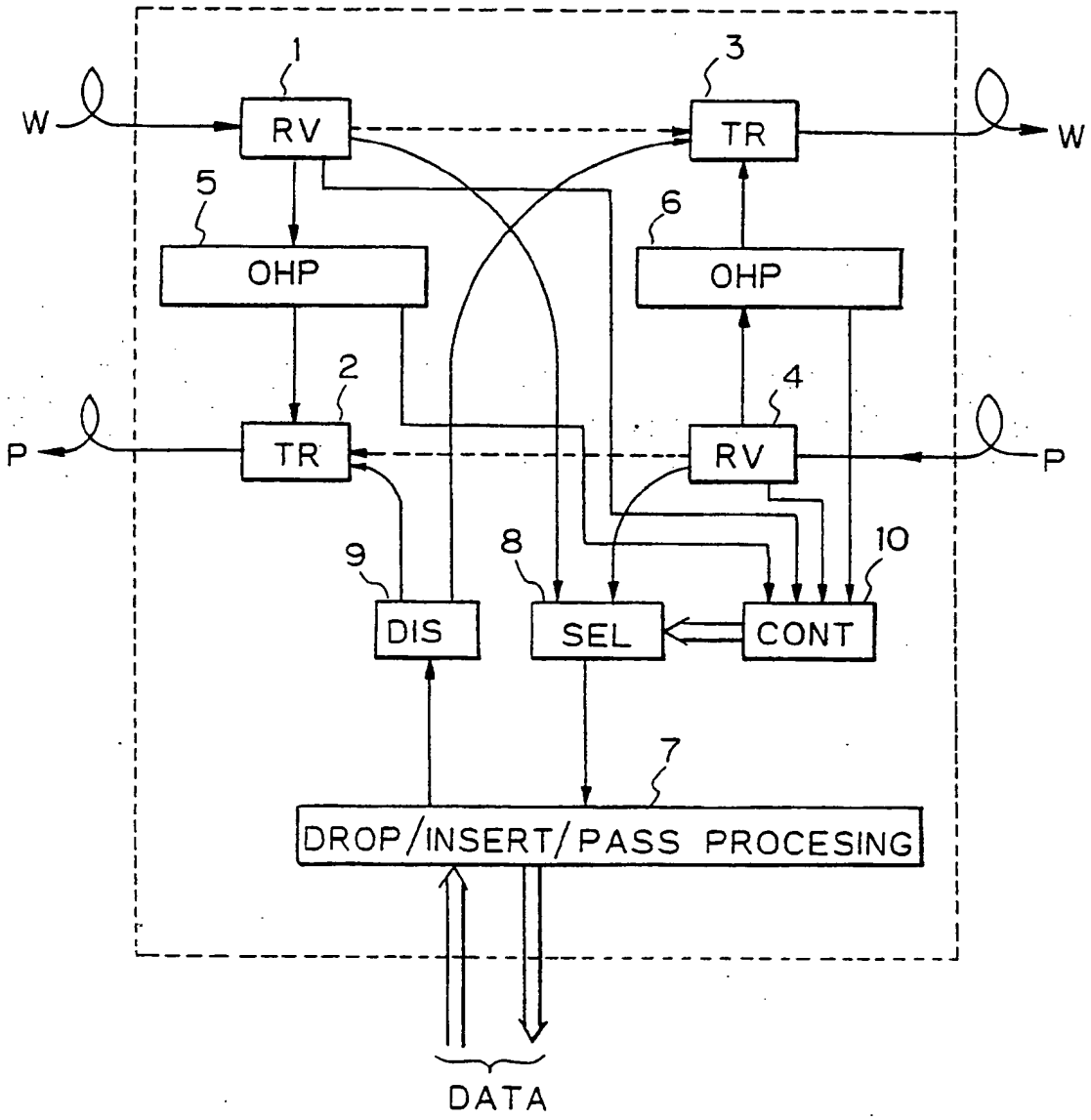


Fig. 12C



BNSDOCID: <EP 0456206A2 I >

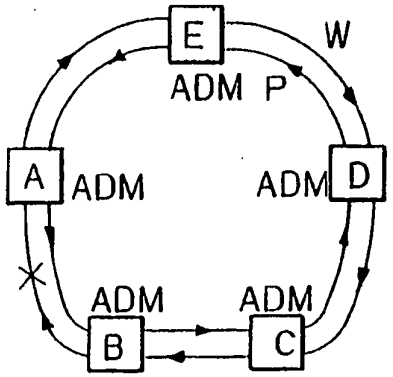
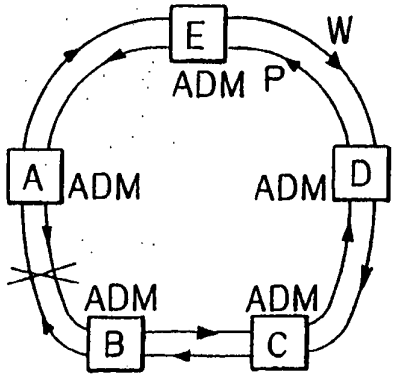
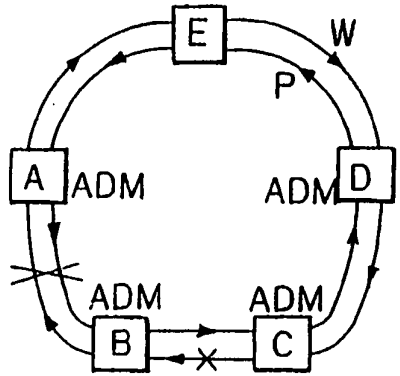
Fig. 13



BNSDOCID: <EP 0456206A2 I >

BNSDOCID: <EP 0456206A2 I >

Fig. 14

RING FAIIURE STATE (1)	RING FAIIURE STATE (2)	RING FAIIURE STATE (3)
		

STATE OF THE F1 BYTE			STATE OF THE F1 BYTE			STATE OF THE F1 BYTE		
TIME	W	P	TIME	W	P	TIME	W	P
t1	F1(A,-,0)	F1(A,-,0)	t1	F1(A,-,0)	F1(-,B,0)	t1	F1(A,-,0)	F1(B,B,0)
t2	F1(A,-,0)	F1(A,-,0)	t2	F1(A,B,0)	F1(A,B,0)	t2	F1(A,B,0)	F1(B,B,0)
FAILURE INDENTIFICATION			FAILURE INDENTIFICATION			FAILURE INDENTIFICATION		
·FIBER CUT BETWEEN A AND B ON W.			·FIBER CUT BETWEEN A AND B ON BOTH W AND P.			·FIBER CUT BETWEEN A AND B ON BOTH W AND P. ·FIBER CUT BETWEEN B AND C ON W.		

* W : WORKING LINE. P : PROTECTION LINE
* TIME t1 : FAILURE OCCURRENCE TIME
* TIME t2 : A CERTAIN TIME LATER AFTER FAILURES OCCURRED.

EP 0 456 206 A2

(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 456 206 A3**

(12) EUROPEAN PATENT APPLICATION

(21) Application number: **91107476.3**

(51) Int. Cl.5: **H04L 12/42**

(22) Date of filing: **08.05.91**

(30) Priority: **09.05.90 JP 119524/90**

(43) Date of publication of application:
13.11.91 Bulletin 91/46

(84) Designated Contracting States:
DE FR GB

(88) Date of deferred publication of the search report:
04.03.92 Bulletin 92/10

(71) Applicant: **FUJITSU LIMITED**
1015, Kamikodanaka Nakahara-ku
Kawasaki-shi Kanagawa 211(JP)

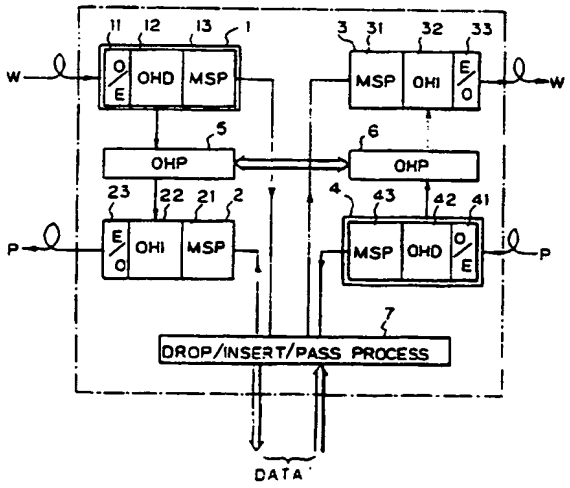
(72) Inventor: **Yamashita, Haruo**
24-4, Sumiregaoka, Kouhoku-ku
Yokohama-shi, Kanagawa 223(JP)
Inventor: **Takizawa, Yuji**
426, Shibokuchi, Takatsu-ku
Kawasaki-shi, Kanagawa 213(JP)
Inventor: **Yamaguchi, Kazuo**
12-21, Toyohara-cho
Hiratsuka-shi, Kanagawa 254(JP)

(74) Representative: **Lehn, Werner, Dipl.-Ing. et al**
Hoffmann, Eitle & Partner Patentanwälte
Arabellastrasse 4
W-8000 München 81(DE)

(54) Fault recovery system of a ring network.

(57) A fault recovery system of a ring network based on a synchronous transport module transmission system, having a fault data writing unit (22,32) for writing, when an input fault is detected by a node, fault data (F1(#n,#k,S)) in a predetermined user byte (UB) in an overhead of a frame flowing through both a working line (W) and a protection line (P) running in opposite directions to each other, and, by detecting the fault data in a supervision node or a node just before the fault position, the supervision node or the node just before the fault position excecutes a loopback operation.

Fig. 7



EP 0 456 206 A3

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 91 10 7476

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	EP-A-0 102 222 (FUJITSU LIMITED) * page 3, line 23 - page 5, line 1 * *	1,10	H 04 L 12/42
A	EP-A-0 091 129 (HITACHI) * abstract * * * page 14, line 16 - page 17, line 9 * *	1,10	
A	US-A-4 648 088 (C.CAGLE) * abstract * * * column 3, line 7 - line 15; claims 6,7 * *	1,12,15, 20,22,26	
A	LASER FOCUS. vol. 23, no. 3, March 1987, TULSA US pages 112 - 120; G.R.CONSTABLE: 'Fiberoptic Lans: The System Integrator's Perspective' * page 119, left column, line 8 - right column, line 16 * * * page 120, right column, line 25 - line 32 * *	12,22	

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

H 04 L

The present search report has been drawn up for all claims

Place of search	Date of completion of search	Examiner
The Hague	19 December 91	STAESSEN B.F.

CATEGORY OF CITED DOCUMENTS

X: particularly relevant if taken alone
Y: particularly relevant if combined with another document of the same catagory
A: technological background
O: non-written disclosure
P: intermediate document
T: theory or principle underlying the invention

E: earlier patent document, but published on, or after the filing date
D: document cited in the application
L: document cited for other reasons

&: member of the same patent family, corresponding document